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THE ARMY'S ROLE IN SATELLITE COMMUNICATIONS DURING THE PAST TWO DECADES

1971 +

Introduction

The U.S. Army has played a basic role in the development of military communications, participating in an impressive number of firsts. This record has been continued by the Army's contribution to the development of military satellite communications, currently by responsibility for the surface environment of the Defense Satellite Communications System (DSCS) and for Army Tactical Satellite Communication Terminals (TACSAT).

The Army has been providing surface terminals for satellite communications since the earliest days of the nation's space effort. Beginning in 1946 with successful exploratory research into the possibility of using the moon, the earth's natural satellite, as a passive reflector, to today's exploitation of the DSCS and TACSAT satellites, the Army has evolved a progression in design and development of such terminals. This development has been accomplished by the application of all facets of the pertinent technology combining the features of radar, microwave radio relay, and tropospheric scatter.

The surface terminal program is now being carried forward through the utilization of new and improved components, concepts, techniques, and equipment with the rapidly increasing state-of-the-art offering a potential for new, advanced, and sophisticated satellite communications capabilities. This article discusses this specialized program, now under the cognizance of the U.S. Army Satellite Communications Agency (USASATCOMA).

Background

The nation's space communication program began in 1946 with Project DIANA. The objective of the project was to obtain radar reflections from the moon. The experiment was successful, yielding useful data regarding radio propagation and moon surface reflectivity. A direct outgrowth of this experiment was the establishment of an operational teletype link between Washington, DC and Honolulu, Hawaii using the moon as a passive reflector.

The nation's first active communications satellite system was developed by the Army under Project SCORE. This experiment demonstrated the feasibility of an active orbiting repeater. The SCORE satellite was launched in December of 1958 and is best remembered as the means by which President Eisenhower broadcast his Christmas address to the world in that year. The satellite and associated terminals had many features which were to affect the design of later terminals. One of the more important was automatic versus manual track, with both techniques being used. It was clear that manual tracking was inefficient, and most subsequent systems employed automatic tracking systems.

Applying the experience gained in Project SCORE, the Army in 1960 designed the COURIER communication satellite system. The COURIER satellite operated on solar cell power, and could handle voice, teletype, facsimile and digital data up to 55 kilobits per second. Ground terminals were located at Fort Monmouth, New Jersey and Salivor, Puerto Rico.

Concurrent with COURIER, the Department of Defense (DOD) initiated development of a synchronous orbit, active communication satellite system known as Project ADVENT. This was a Tri-Service program under Army management. The program objective was to demonstrate the feasibility of achieving long distance communication by real time microwave radio circuits through an active repeater in synchronous, equatorial orbits. The ADVENT satellites were to be exercised by fixed terminals (AN-FSC-9) at Fort Dix, New Jersey and Camp Roberts, California, and a shipboard terminal aboard the USNS Kingsport. These terminals were designed to operate at 8 GHz on the up link, and at 2 GHz on the down link. While the ADVENT project itself was redirected, these terminals were used in subsequent programs.

During the development of ADVENT, the Army was assigned the responsibility of providing the surface terminals for NASA's Project SYNCOM. DOD and NASA agreed that the SYNCOM program should make maximum use of existing facilities and accordingly the Army (USASATCOMA) was directed to act as the DOD agent to provide the surface communication terminals and to perform communication test planning and direction.

Two SYNCOM satellites were orbited, functioning as active repeaters. SYNCOM II, launched 26 July 1963, was placed in an inclined synchronous orbit. SYNCOM III, launched 19 August 1964, was placed in an equatorial, synchronous orbit. The SYNCOM satellites were spin stabilized, powered by a solar cell system augmented by nickel-cadmium batteries. Communication frequencies of 8 GHz for the up link and 2 GHz for the down link were selected for maximum compatibility with the ADVENT stations. The telemetry and command system operated in the VHF band.

The SYNCOM earth terminals (AN/MSC-44) built concurrently with the ADVENT stations, were transportable types to permit deployment to various overseas test locations, providing a flexible ground environment. Each terminal consisted of eleven vans in the transport configuration and could be transported in C-124 and C-130 aircraft.

Since the Fort Dix, Camp Roberts, and USNS Kingsport terminals were also to be included in the SYNCOM system, these terminals were modified to operate at the specific SYNCOM frequencies and were provided with suitable terminal equipment.

The success of the SYNCOM system and the resulting highly satisfactory military communications networks resulted in specific investigation of the potential of satellite communications for military task force use. In December 1963, USASATCOMA demonstrated the capability of an experimental, highly transportable terminal, designated as Mark IV(X), with SYNCOM II. The success of this demonstration led to the employment of the terminal during May 1964 in support of Exercise Desert Strike in the vicinity of Needles, California. An improved version of the early experimental terminal, designated AN/TSC-55, was then procured by the Army and, together with the original Mark IV(X), operated in the SYNCOM system.

Either the Mark IV(X) or the AN/TSC-55 terminal, in its transport configuration, could be carried in a single C-130 aircraft along with the personnel necessary for 24 hour-per-day operation.

Defense Satellite Communications Program (DSCP)

In May 1962, prior to completion of either the ADVENT or SYNCOM programs, the DOD reoriented the Satellite Communications Program modifying the Army's role to include the management of research, development, and fabrication, installation, and logistics of an expanded land-sea surface environment for satellite communications.

SATCOM Terminal AN/MSC-46

The first terminal specifically planned for the reoriented DSCP was the air-transportable AN/MSC-46, which incorporated the design advances resulting from earlier efforts. The terminal was housed in seven vehicles. Transportable in C-133 or now the C-5A aircraft, the entire terminal is capable of erection without benefit of heavy equipment. The antenna is normally housed within a 68-foot diameter rigid geodesic radome. The reflector is 40 feet in diameter and utilizes a unique dielguide feed that provides illumination efficiencies of 75%.

There were 14 AN/MSC-46 terminals procured and they are currently deployed as a part of the Defense Communications System in all areas of the world and the Continental United States. These terminals were deployed beginning in 1966 and were declared operational in July 1967.

The AN/MSC-46 terminal operates with a transmitting band of 7900-8400 MHz and receives in a band of 7250 - 7750 MHz. When employed with the Phase I DSCP satellites, which are in near synchronous equatorial orbit, the terminal provides up to 12 high quality duplex voice channels. In addition to its normal use in a Frequency Division Multiple Access

(FDMA) mode the terminal also has an alternate Spread Spectrum Multiple Access (SSMA) mode which gives a measure of antijam capability.

The terminal uses a low noise, cryogenically cooled parametric amplifier receiver and a 10 KW high power klystron transmitter. The system noise temperature is 210° K.

SATCOM Terminal AN/TSC-54

The AN/TSC-54 is the first military SATCOM terminal designed for quick-reaction contingency deployment. There were 13 of these terminals produced and deployment to worldwide sites began in late 1967. The complete terminal consists of an antenna trailer, operations shelter and two 400-hertz diesel generators. The entire terminal can be torn down or set up in less than two hours and is transported, together with its crew members, spares and fuel for 72-hour operation in a single C-130E aircraft. Communications capability is a single-voice channel and two out-of-band teletype channels. FDMA and SSMA equipment is also provided as in the case of the AN/MSC-46.

The antenna reflector uses a unique design consisting of a cloverleaf shape and four dielguide feeds. Monopulse tracking is used. The low noise receiver utilizes an uncooled parametric amplifier with a noise temperature of 125°K. The transmitter has a peak power output from the high power klystron of 5 KW. The transmitting and receiving frequency bands are identical to the AN/MSC-46.

PHASE I SATELLITES

The satellites with which these terminals operated were launched between 1966 and 1968. There were four launches and the satellites were placed in random subsynchronous equatorial orbits. Each launch had between four and eight satellites arranged in a dispensing mechanism mounted on the booster. Each satellite (26 total) is a 24-sided polygon, 36 inches in diameter and 32 inches high, covered with solar cells, and weigh approximately 100 pounds in orbit. The satellites are spin stabilized and contain redundant three-watt traveling wave tubes and provide output power that is radiated in a toroidal antenna beam pattern.

TACTICAL SYSTEMS

The experience gained during exercise "Desert Strike", when the MARK IV(X) terminal operating through the SYNCOM satellite, was supporting Tactical Strike Troops in the field, reinforced the belief that satellites could provide an extremely useful means of communications for Tactical Field Army units.

LES-5 Program

In 1966, a program was initiated to prove this theory. In preparation for the launch of a UHF satellite in 1967, the Army, as well as the other services, began to build small transportable terminals. USASATCOMA engineers designed and, with the assistance of the Army Electronics Command Laboratories, built two jeep-mounted terminals, two shelter terminals mounted in 3/4-ton trucks and a large terminal mounted in a 26-foot van. The jeep and truck mounted terminals used either a yagi or a collapsible helical antenna mounted on a tripod, while the 26-foot van used a quad-helix antenna.

In 1967, the Lincoln Experimental Satellite No. 5 (LES-5) was launched. It was placed into a subsynchronous equatorial orbit with a drift rate of approximately 30^{o} a day. As stated before, it was a UHF repeater, and had an effective radiated power of approximately 50 watts. Its subsynchronous orbit made it visible to any point on the surface of the earth for about 4 days out of every 12.

The Army terminals, called the EASTT equipment, for Experimental Army Satellite Tactical Terminals proved highly successful. They were first used to conduct a comprehensive series of technical tests to verify their predicted performance characteristics. This accomplished, the terminals were then deployed to determine their performance in varied environments. They travelled to Fort Huachuca where they were involved in electromagnetic interference tests; to Panama for jungle tests; and to the island of Vieques off Puerto Rico for participation in an amphibious exercise. In all areas, the system performed as well as, or better than, had been predicted.

The terminals provided full duplex, single-channel voice traffic through LES-5, as well as teletype and facsimile transmission.

As the success of the LES-5 satellite and the associated surface terminal became known, interest in participating grew. Several members of the North Atlantic Treaty Organization (NATO) expressed the desire to participate in the program and, in 1967, a Memorandum of Understanding was drawn up which established a NATO TACSATCOM Program. Six NATO nations (Belgium, Canada, Italy, The Netherlands, Norway, and the United Kingdom) agreed to participate with the United States in a cooperative research and development program. Some participants built their own ground terminals, while others purchased duplicates of the EASTT 3/4-ton terminal. The program, which is still active, has resulted in the development of considerable satellite communications expertise on the part of the NATO nations, and a good deal of valuable technical data has been made available to the United States.

LES-6 Program

While the testing of the EASTT terminals with LES-5 was under way, the Lincoln Laboratories were fabricating their next UHF satellite called Lincoln Experimental Satellite No. 6 (LES-6).

When launched in September 1968, this new, more sophisticated satellite was placed in a stationary or synchronous equatorial orbit at a longitude of 109°W. Since it was equipped with an electronically despun antenna, it provided much higher up and down link power, thus increasing its over-all capacity. The EASTT terminals which had been operating with LES-5 were retrofitted to operate at the slightly different frequencies used for LES-6. A formal test program was conducted which verified the improved performance of the new system.

Concurrently with their test program, the United States modified the Memorandum of Understanding with the interested NATO nations to allow them to use LES-6. Based on this agreement, the satellite was moved to 40°W longitude, which provides good look angles for both European and North American participants.

TACSAT I Program

Experiences during the LES-5 and LES-6 programs convinced planners that a further step should be taken in the development of satellite communications technology for specific application to the tactical environment.

Terminals used in the LES series of satellite tests had been fabricated, using almost exclusively off-the-shelf components. It was decided that a satellite of completely new design and new earth terminals to operate with it would be fabricated.

The satellite, designed and built by Hughes Aircraft Company, is the largest communications satellite ever built. It is 28 feet high and 9 feet in diameter. It is capable of operation in both the UHF and SHF bands. The UHF antennas consist of five helices, while the SHF antennas are standard horns. The satellite was designed so that if the proper modes were selected by command from the ground, signals could be received by the UHF antenna and broadcast to earth via the SHF antenna, or vice versa. Thus, UHF and SHF terminals are capable of inter-operation.

To operate with this new satellite, two families of advanced development terminals were fabricated.

In the UHF family, there are four major types:

The alert receiver, AN/TRR-32, a receive only unit, capable of being handcarried and providing alert or warning messages.

The teampack terminal, AN/TRC-156, configured in packages for transportation by a three-man team and capable of providing a half duplex voice channel through TACSAT I.

The jeep terminal, AN/MSC-58, with the communications equipment mounted in the jeep and the engine generator and fuel carried in a 1/4-ton trailer. This equipment can provide a full duplex voice channel through TACSAT I.

The 1-1/4-ton shelter terminal, AN/TRC-157, with communications equipment in the shelter, and engine generator in a trailer. This terminal also provides a full duplex voice channel. It also generates the alert or warning messages which are received by the alert receiver.

The SHF family consists of the same basic units. They are:

The Alert Receiver, AN/TRR-30.

The Team Pack, AN/TSC-79.

The Jeep Terminal, AN/MSC-57.

The 1-1/4-ton Shelter Terminal, AN/TSC-89. This terminal can provide, in addition to the full duplex circuit, a six-channel PCM trunk through TACSAT I.

In addition to the terminals above, specialized units were designed for use on board ships, and fixed and rotary wing aircraft.

TACSAT I was launched in February 1969. From then until June 1970 an intensive test program was conducted to determine the technical capabilities of the system. The TACSAT I satellite is presently located over the international date line in the Pacific Ocean area.

The system again proved the feasibility of tactical satellite communications.

As a result of interest aroused by the R&D phase of the TACSAT I program, it was decided to use the system in an operational role. The Joint Chiefs of Staff directed that the existing equipment be used to provide what is called an "Interim Operational Capability (IOC)", until a fixed production version of Tactical Satellite Communication terminals could be built. The terminals now in use in the IOC perform a wide variety of missions. Using both the LES-6 and TACSAT I satellites, Navy terminals handle operational traffic between points which before could not be linked together directly. Airborne terminals are now capable of communicating over long distances.

The highly transportable Army ground terminals have provided circuits for use by the President on his trip to Yugoslavia; for use in the communication nets for recovery of spacecraft; for tactical communications during military exercises; for both United States and NATO, in such areas as Western Europe, Alaska, Korea, and many sites within the Continental United States.

For example, the IOC terminals supported both field exercises REFORGER II in 1970 and REFORGER III in 1971. Five UHF terminals were provided in support of the 1st Infantry Division. One terminal was assigned to Division Headquarters with others being assigned to the Tactical Operations Center and to the maneuver battalions. The IOC has provided and continues to provide a highly flexible and reliable communication means which fills many gaps left by more conventional communications systems.

Future of Strategic Satellite Communications Systems

The Phase II DSCS Program represents the next progressive step forward in the military satellite communications program. Phase II is characterized by larger, greater capacity and more versatile synchronous orbiting satellites, modified Phase I earth terminals and the introduction of new terminals incorporating redundant subsystems to provide high reliability and initially utilizing FDMA, but later replaced by all digital communications employing Time Division Multiple Access (TDMA).

The Phase II satellites weigh approximately 1100 pounds in orbit. They are 9 feet in diameter, 13 feet high and have an Effective Radiated Power (ERP) of either 28 DBW or 40 DBW. The satellite employs two different types of antenna systems. One is an earth coverage antenna, which effectively covers the visible earth and the other employs two steerable narrow beam parabolic antennas that cover up to 1000 miles diameter on the Earth's surface. The satellites are spin stabilized with the communications equipment mounted on a mechanically despun platform so that the two antenna systems always point toward earth. The satellites are powered by solar cells arranged around the outside of the satellite body and utilize on-board storage batteries for eclipse operation.

The satellites have a design life of five years, redundance in all active components and can be commanded to move to various longitudes during the life of its on-board propulsion system. The greater capability of these satellites allow the use of large, high capacity earth terminals or small, highly mobile, combat user terminals.

The Phase II Program is divided into three distinct stages, i.e., Stage Ia, Stage Ib and Stage II. These stages will be implemented progressively over a period of the next four to five years.

Stage Ia

Stage Ia began with the launch of the first Phase II type satellite which occurred 2 November 1971. Stage 1a utilizes the Phase I Terminals (AN/FSC-9, AN/MSC-46 and AN/TSC-54) plus selected terminals of other services/government agencies. The Phase I terminals were modified to be frequency compatible with the new satellites which vary somewhat from the Phase I satellites. The terminal modifications basically consisted of crystal oscillator changes and modifications to the tracking loops to allow auto-track of the Phase II satellite biphase modulated beacon.

No increase in channel capacity was provided for any of the terminals. The AN/FSC-9 and AN/MSC-46 continue to provide a maximum of 12 voice channels and the AN/TSC-54 continues with one voice channel but with DCS quality. However Stage Ia provides a larger link capacity and multiple access to a single satellite. Frequency Division Multiple Access (FDMA) and Spread Sprectrum Multiple Access (SSMA) is employed.

In FDMA all terminals may transmit continuously but each on a separate frequency. Transmitter power balance between any pair of terminals becomes a very important parameter to control in this type of multiple access.

In SSMA all terminals may transmit continuously and on the same frequency, but each terminal uses a code to identify its transmission. This enables the receiving terminal to sort out the transmissions and decode only those intended for it. The coding technique causes the signal bandwidth, or spectrum, to be widened several orders of magnitude.

All terminals are compatible with the Phase II frequency plan and have accurate control of the transmitter power output. Additionally selected AN/MSC-46 terminals are equipped to monitor the performance of the Phase II satellite. Concurrent with Stage Ia operations, modifications are being designed, constructed and implemented which will significantly change the terminals' capabilities for Stage Ib.

Stage Ib

Stage Ib begins when the terminals are modified to allow the system network to operate in a nodal/non-nodal and contingency environment. The Stage Ia system operates on a point to point basis, i.e. one terminal communicating with another terminal via the satellite. The Stage Ib system will operate in such a way that one nodal terminal can communicate via a satellite with many terminals simultaneously. The outlying terminals could be either non-nodal or contingency terminals. Stage Ib could be considered as a multi-point system. Greater interconnectivity among the terminals could be achieved by adding more transmit and receive chains to other terminals in the network.

Although a wide variety of system configurations is possible a typical configuration would be a nodal terminal (AN/MSC-46) providing 12 duplex voice channels to each of three non-nodal AN/MSC-46 terminals and three duplex voice channels to each of three AN/TSC-54 terminals. A link also could be provided between the nodal terminal to a fourth AN/MSC-46. This link could be used for 12 analog voice channels or alternatively be equipped with PSK modems and provide a simplex imagery link or eight digitized wideband secure voice/clear voice channels.

During Stage Ib the Phase I terminals will be further modified to provide multiple carrier capability at all terminals. This will generally be accomplished by adding additional up/down converters to the terminals. Also a communication subsystem will be added to the terminals which houses the multiplex equipment, FM modems, spread spectrum equipment (AN/URC-61 or AN/URC-55) and ancillary items. Because of the increased importance of the nodal terminals in the Stage Ib network there will also be some reliability/availability modifications made to selected AN/MSC-46, AN/FSC-9 and AN/TSC-54 terminals. These modifications generally consist of relocation of equipment to allow more maintainability access, addition of redundant subsystems, and improvement in prime power distribution.

After modifications are complete all terminals will utilize either the narrow beam antennas or the earth coverage antennas to the fullest extent of system capability. The system at this time will continue to function as an FDMA/SSMA system with expanded capability, depending upon equipment complement, to handle voice and high speed data requirements.

Concurrent with Stage Ia and Ib, research and development is being conducted to develop new ground terminals with the capability for incorporating Time Division Multiple Access (TDMA), Spread Spectrum Multiple Access (SSMA), Pulse Code Modulation (PCM) equipment for analog to digital conversion, and Biphase Shift Keying Modulators (BPSK).

In a Time Division Multiple Access (TDMA) system each terminal transmits for a short time but at a greatly increased digital rate, then stops while each of the other terminals has its turn. The time periods are very short, measured in nanoseconds, and the modulation equipment is designed in such a way that the user does not know about the interruptions.

In the TDMA mode only one carrier accesses the satellite at any instant, thus full satellite power can be used without causing mutual interference problems. Also the inclusion of additional terminals to the system can be readily accomplished by adjusting time slots rather than by changing frequency. Utilization of this mode of operation results in an extremely efficient use of the satellite subsystem.

The new terminals to be added are currently known as Heavy Transportable (HT) and Medium Transportable (MT) and will be connected with appropriate communication subsystems. Stage Ib will continue until such time as new equipment is introduced into the system configuration to allow all digital communications capability. This point in the program is identified as Stage II.

Stage II

The HT/MT (AN/MSC-60 and AN/MSC-61) terminals are currently under development and one of each type is scheduled for delivery in 1972. After a period of testing, additional terminals will be produced for worldwide deployment. Generally, the AN/MSC-60 would be used at major nodal points and AN/MSC-61 at non-nodal locations.

The AN/MSC-60 prototype is a semifixed installation design capable of being relocated to a new site. The total weight of the AN/MSC-60 is approximately 400,000 pounds. The antenna reflector consists of a solid surface, 60-foot diameter, high efficiency paraboloid utilizing a five-horn, pseudo-monopulse feed system. Dual, cryogenically cooled parametric amplifiers, 500 MHz bandwidth, are located at the rear of the antenna reflector. The major electronic components of the system are located in two vans; one houses the transmitters and heat exchangers, the other the RF operations equipment including control console. A third van for maintenance and supply can be added to the system.

The terminal is designed to be extremely reliable and versatile. It receives from the satellite in the same frequency band as the Phase I terminals and processes the information to 70 MHz or 700 MHz IF outputs for application to demultiplex equipment. The terminal also processes information in reverse fashion for transmission to the satellite. The transmitter van houses redundant low power amplifiers (3KW TWT), the high power amplifier (8 KW klystron), transmitter monitor equipment and the primary power switchgear. The RF and operations van houses multiple up and down conversion equipment and their related frequency generation equipment, transmit interfacility link (IFL) amplifier, test and monitor equipments, automatic control equipment and the terminal control console. A high level of subsystem redundancy plus automatic fault location and automatic switch-over equipment has been incorporated because of the major considerations given to operational availability and reliability.

The AN/MSC-61 terminal weighs considerably less than the AN/MSC-60 and is readily transportable for contingency situations, if required. It can be installed on an unprepared site (graded and cleared) in approximately 4 to 6 hours. This is in contrast to the AN/MSC-60 which requires a prepared site and 45 to 60 days to install. Except for the AN/MSC-61 antenna subsystem, which is similar to that of the AN/TSC-54, the major subsystems of the AN/MSC-61 are identical to the AN/MSC-60. The AN/MSC-61 and AN/MSC-60 vans have been designed to be interchangeable. The van equipment, as normally outfitted for the AN/MSC-61, will not include the redundant low power TWT amplifier and will have less up and down conversion equipment.

The maintenance and supply van is designed to supply the logistic support for either the AN/MSC-60 or AN/MSC-61. The van is divided into two sections (maintenance and supply). The maintenance section houses the test equipment, tools, documentation and work benches necessary for preventive and diagnostic maintenance of the terminal electronic equipment. The supply section is isolated from the maintenance section and contains space to provide storage for the replaceable units and small spares required to maintain operations.

The Communications Subsystem for Stage II will contain the signal processing equipment necessary for all digital communications via satellite. Typical of the equipment contained in a communication subsystem is Time Division Multiplexer (AN/GSC-24), Pulse Code Modulation Multiplexer, (TD-968), Time Division Multiple Access equipment, Spread Spectrum Multiple Access equipment, (AN/USC-28), Encoder/Decoder devices and similar equipments. These equipments interface as a complete subsystem to the AN/MSC-60 or AN/MSC-61 at the 70/700 MHz IF frequency port. When fully connected the AN/MSC-61 or AN/MSC-60 together with the communication subsystem constitute an earth terminal.

FUTURE OF TACTICAL SATELLITE COMMUNICATIONS SYSTEMS

In addition to providing high capacity links between large strategic type terminals, the new and more powerful satellites will also permit the design of smaller and simpler-to-operate earth terminals for use by the field army.

Continuing the activities begun in the IOC, the Army SHF terminals will be modified to operate with the narrow beam antennas of the Phase II DSCS satellites described above. By working with the narrow beam, the capacity of the 1-1/4-ton terminal will be increased to a 12-channel trunk.

In parallel with this effort, a new group of production type tactical terminals will soon be under construction. Taking advantage of lessons learned in the earlier TACSAT I program, the Army plans to build three types of terminals: one SHF version to fit in a 1/4-ton trailer, an SHF model to fit in a 1-1/4-ton truck, and a UHF terminal, with a low capacity but capable of being transported and operated by a single soldier.

The SHF terminals will provide high data rate multichannel trunking, while the UHF terminals will be used for low data rate, full duplex and half duplex, single channel netting.

It is planned to employ satellite communications in the field army from theater army headquarters down to brigade level in very much the classical style that the Army now employs Tropo Scatter, line-of-sight and high frequency radios in command and control. The exploitation of satellite communications will permit a considerable reduction of these conventional radio systems and permit the mix of satellites and conventional means to more effectively serve a wide variety of combat situations. The multichannel requirements for intra-theater communications will generally require the use of the satellite SHF narrow beam antennas. These beams will be shared by the Marine Corps, who have similar requirements but on a much smaller scale.

The size of the satellite system is based upon satisfying the bulk of satellite communications requirements represented by the two corps, eight division field army, realizing that this is a stylized model which is subject to considerable variation depending upon contemporary circumstances and the combat situation.

During the time frame 1976 - 1979 all SHF users will be multichannel trunking with trunk groups of 6, 12, 24 and 96 channels in Time Division Multiplex, PCM. UHF network users will be single channel push-to-talk voice, or full/half duplex teletype or data, with some burst transmissions. The UHF will also be used to serve the very critical need within the Army for control of fixed and rotary wing aircraft in the Air Traffic Management System (ATMS) and the Semi-Automated Flight Operations Center (SAFOC). One-way broadcast warning transmissions and communications control orders will also be at UHF and will to the greatest extent use the technology and subsystems being developed by the Navy in connection with the Fleet Satellite Communications System (FLEETSAT).

It is planned to continue TDMA investigation and development applicable to Army applications, with the intent of phasing in this form of multiple access as the techniques are developed for both the satellite earth coverage and narrow beam antenna applications. Terminal designs now being planned will permit this phasing in with minimum terminal modification.

Summary

In reviewing the years since Project DIANA, the trends are obvious. Starting with large, cumbersome earth terminals and passive satellites, quick progress was made to the small, active satellite repeaters, which permitted the reduction of the earth terminals to a manageable size and increased their flexibility.

From that point on, each increase in the capability of the satellite, such as high power solid state transmitters, electronically and mechanically despun antennas, and prime power system of steadily increasing capacities, have permitted corresponding increases in the capabilities of large earth terminals and made possible the development of the small, light, easy to operate, highly transportable tactical terminals.

Much has been achieved in just a few short years and the coming years appear to hold the promise of even more gratifying developments.